Coleoptera
(Ore. Pine Ips &
Mtn. Pine Beetle)

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MOUNTAIN PINE BEETLE AND OREGON PINE IPS
- 1963 Exploratory Studies -

By

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SUMMARY

Studies were initiated during 1963 on the mountain pine beetle, Dendroctonus monticolae Hopkins (= ponderosae Wood), and the Oregon pine ips, Ips oregonis (Eichhoff), the two major bark beetle pests of second-growth ponderosa pine in the Pacific Northwest. These studies were the first in several years on pine bark beetles in Oregon and Washington. Briefly, 1963 results were as follows:

Mountain Pine Beetle

1. The mountain pine beetle produced only one generation in pole-sized ponderosa pine at Pringle Falls during 1963. Overwintered old parent adults re-emerged in the last two-thirds of June, but did not successfully establish additional broods in young ponderosa pine. New adults emerged from about the third week in July through the first week in September, with peak emergence during the first half of August.

2. Study sites suitable for long-term investigation of silvicultural relations of the mountain pine beetle in ponderosa pine were found on the Yakima Indian Reservation and on the Fremont and Deschutes National Forests. Additional prospective areas will be examined in early 1964.

Oregon Pine Ips

1. In general, the Oregon pine ips completed two generations during 1963 in central Oregon, but lesser features of its seasonal history varied between areas according to elevation. At 3,000 feet, the peak spring attack period was during the second and third weeks of May; the peak attack period by first generation adults was during the middle of July; and the second generation reached the adult stage in late August and early September. The same seasonal history events occurred about a week later at 4,300 feet, about two weeks later at 4,800 feet, and three to four weeks later at 5,300 feet.

2. Shape of the third declivital spine was confirmed as a reliable indicator of sex in the Oregon pine ips. Sex ratio varied at different points in the ips seasonal history, being approximately 1.5 females per male for the populations entering and completing the overwintering period, approximately 1 female per male for new adults prior to emergence, and approximately 3 females per male at attack. In "feeding" attacks, sex ratio was 1.5 females per male, and attack densities were so high that only seldom was any cambial tissue available for brood development. Rearings made to investigate the influence of sex ratio on ips attack habits and brood production were inconclusive.

3. Most ponderosa pines completed their 1963 radial growth by mid-summer, but a few trees continued to grow well into September. Oleoresin exudation pressure measurements were unsuccessful because resin flow was not sufficient to activate the gages. Soil moisture did not become limiting to immature ponderosa pines at any time in 1963. Forced ips attacks made at three intervals during the season were all unsuccessful.

MOUNTAIN PINE BEETLE AND OREGON PINE IPS

Progress Report on 1963 Exploratory Studies

by

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Division of Forest Insect Research

INTRODUCTION

A change in the relative importance of the insect enemies of ponderosa pine in the Pacific Northwest is resulting from the conversion of large acreages of virgin timber to the second-growth condition. The pests of open-grown, uneven-aged, mature and overmature stands are decreasing in importance, while those of close-grown, even-aged, immature stands are gaining in importance. Foremost of the pests of second-growth ponderosa pine are the mountain pine beetle, *Dendroctonus monticolae* Hopkins,[1] and the Oregon pine ips, *Ips oregonis* (Eichhoff). The threats which these two bark beetles pose to young pine stands have been recognized, and the need to determine effective forest management practices for their control has been given high priority by the Northwest Forest Pest Action Council (25).

The studies described herein represent the first comprehensive research done in several years on pine bark beetles in Oregon and Washington. They were begun in October 1962 with the employment of the author as a project entomologist. Much time was consumed initially in becoming oriented to the problems, in reviewing the literature, drafting a problem analysis of the mountain pine beetle, in preparing a work plan for the 1963 season,[2] and in acquiring needed equipment. Field observations were begun in March 1963, and soon thereafter a field station was established at the Pringle Falls Experimental Forest headquarters (Figure 1) which is located about 30 miles southwest of Bend, Oregon. Most 1963 studies were conducted in the Pringle Falls area, but some observations were made in the Warm Springs Indian Reservation and on the Fremont and Malheur National Forests.

1/ S. L. Wood's 1963 revision of the bark beetle genus *Dendroctonus* Erichson. (Great Basin Nat. 23:1-116, illus.) submerges *D. monticolae* under *D. ponderosae*. However, the former name is retained in this report.

2/ Sartwell, C., Jr. 1963. Oregon pine ips and mountain pine beetle - work plan for exploratory studies, season of 1963. Pacific NW Forest and Range Expt. Sta., Div. of Forest Insect Res. June 15, 1963. 16 pp. (unpublished).

Figure 1. Insectary and cages at Pringle Falls field station.

MOUNTAIN PINE BEETLE STUDIES

Background of Problem and Previous Research

Depredations of western white pine, sugar pine, and lodgepole pine by the mountain pine beetle (Dendroctonus monticolae Hopk.) have caused it to be described as the most destructive species of the genus Dendroctonus (9). However, killing by this bark beetle in ponderosa pine seldom has been of more than secondary importance. But man, by both direct and indirect actions, has caused great changes in the ponderosa pine forests of the Pacific Northwest, and these changes are regarded as favorable to greatly increased mountain pine beetle activity.

The most important of the changes appear to have resulted from logging and fire prevention. The forests have been greatly reduced in age by logging; much of the old-growth timber has been removed, permitting establishment of large acreages of second growth. The development of effective fire prevention and control programs has almost removed fire from ponderosa pine ecology (41), and, because fire was the most dynamic of the natural thinning agents, the young stands are often overstocked, and growth in many has stagnated. Furthermore, because of the nature of the seeding habits of ponderosa pine and its intolerance to shade, an even-aged condition exists in most second-growth stands (23). It is in these young, overstocked, even-aged stands (Figure 2) that mountain pine beetle killing is increasing; it may well become intolerable unless effective silvicultural practices are determined for controlling the beetle.

Previous studies offer little toward an understanding of the beetle's silvicultural relations with ponderosa pine because the bulk of mountain pine beetle research has been concentrated on tree hosts other than ponderosa pine. Only the studies by Eaton (11) and Clements (7) have dealt significantly with the silvicultural relations of D. monticolae in young ponderosa pine stands.

Earlier studies by Evenden, Bedard, and DeLeon (10, 12) in northern Idaho, Struble (12, 35) in California and Patterson in Oregon (26), have produced much knowledge of the biology of the mountain pine beetle, and further biological studies by Reid (29) and Shepherd (33) in Canada and Cole (8) in Utah are presently underway. Yet, in spite of the numerous studies on the biology of D. monticolae, none of note have been done on the beetle in ponderosa pine.

Another source of knowledge which will be useful in making studies of the mountain pine beetle is the research done on the Black Hills beetle, D. ponderosae, by Beal (3), Knight (20) and Mogren (22), and which is now being carried on by McCambridge and Stallcup.

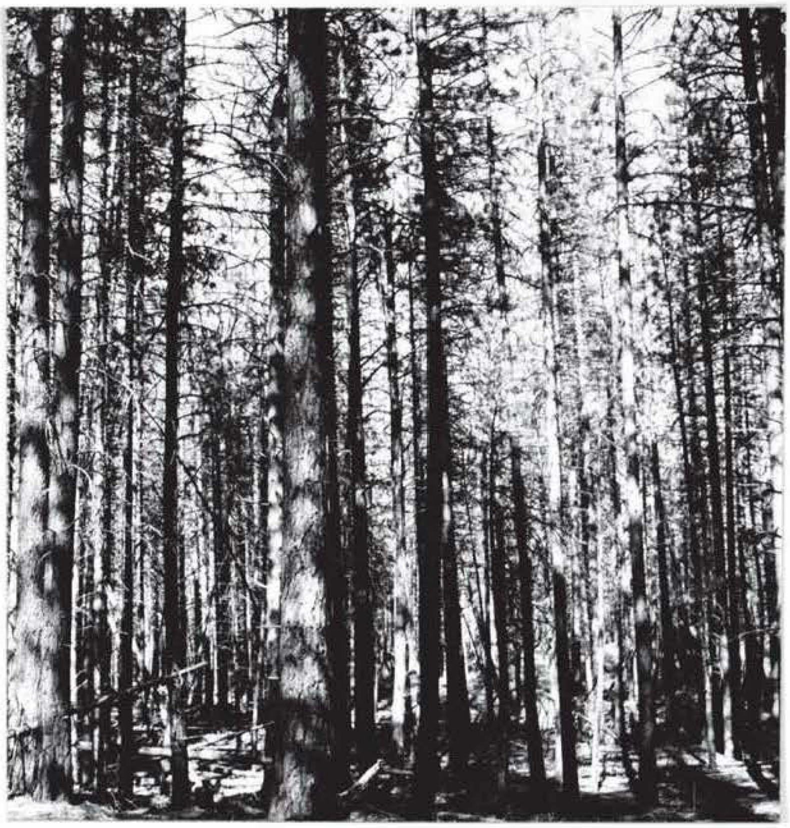


Figure 2. Densely stocked, even-aged stand of ponderosa pine, about 70 years old, in which mountain pine beetle is active. Largest tree in foreground is about 14" d.b.h.

Recent and current research on general bark beetle host relations by Vité (39, 40) and Smith (34) in California, Rudinsky in Oregon (30) and Chararas (6) in France, to name but a few, will contribute to understanding the more fundamental aspects of the mountain pine beetle's relationships with ponderosa pine. It should be pointed out, however, that those studies are concerned mostly with bark beetle relationships with individual trees, while the mountain pine beetle problem, at least from the practical standpoint, is one related to stand conditions. Therefore, a need exists to determine if the results of studies of individual trees are applicable to stand conditions in the forest, and, if applicable, how they might be applied.

Figure 3. Dead ponderosa pine with bark removed to show parent galleries of mountain pine beetle.

Broad Study Objectives.

The primary, long-term objective of these studies of the mountain pine beetle is to determine silvicultural methods for reducing its damage in immature ponderosa pine stands. To meet the primary objective, a better understanding will be sought of the beetles' biological and ecological relationships with ponderosa pine. Because the problem has many aspects, research will necessarily extend over a long period. Different aspects will be investigated each year, and, accordingly, immediate objectives will vary from year to year. The immediate objectives for 1963 were:

1. To increase familiarity with the problem.

2. To initiate a study on the seasonal history of the beetle in Central Oregon ponderosa pine.

3. To locate suitable study sites for long-term investigations of the silvicultural relationships of the beetle and ponderosa pine.

1963 Studies.

Study Number 1: Seasonal History in Central Oregon.

Objective: To determine the seasonal history of the mountain pine beetle in ponderosa pine in the Pringle Falls area, Deschutes National Forest, during 1963.

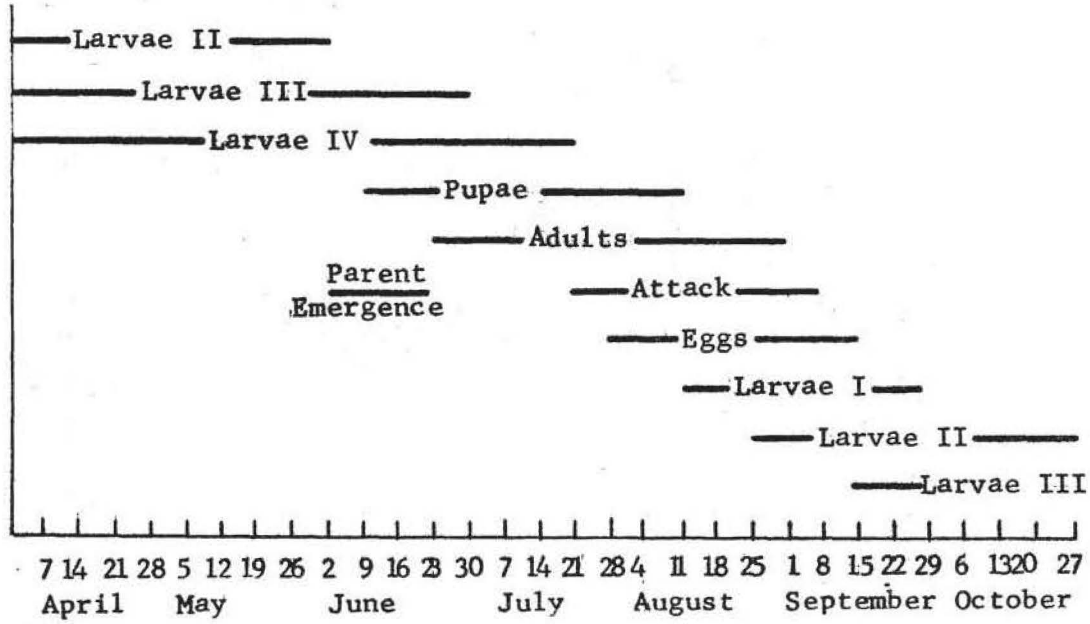
Methods: Field observations in the Pringle Falls area during 1963 were made at monthly intervals from March to mid-May, at about weekly intervals from mid-May until late September, and again at monthly intervals from October through December. Cagings were initiated at the Pringle Falls field base in early June to guide and aid in interpretation of the field observations.

Results: The approximate seasonal history of the mountain pine beetle in the Pringle Falls area is shown in Graph 1. The insect produced only a single generation during 1963. It passed the winter of 1962-63 in the second, third, and fourth larval instars, and also in the parent adult stage. The parent adults abandoned the brood trees during the last two-thirds of June. A caging of these emerged parent beetles in late June produced pupae and callow adults by the end of August, but in the wild the parents did not establish an additional brood in living ponderosa pine during June. Emergence of new adults (from overwintered larvae) began during the third week in July and continued until early September, with peak emergence occurring during the first two weeks in August. Brood established by the new adults entered the 1963-64 winter in the second and third larval instars.

The overwintering parent adults did not extend their galleries and lay eggs in the early spring before abandoning the brood trees. Instead, they expanded their feeding tunnels at or near the head of the egg galleries. Observations in October 1963 indicated that formation of the feeding tunnels actually begins prior to or early in the overwintering period. The significance of the failure of parent females to resume egg laying in the spring is not established. However, Cole (8) in comparing an epidemic with an endemic infestation of D. monticolae in lodgepole pine, found that the two infestations differed only in that parent females in the epidemic infestation resumed egg-laying in the spring.

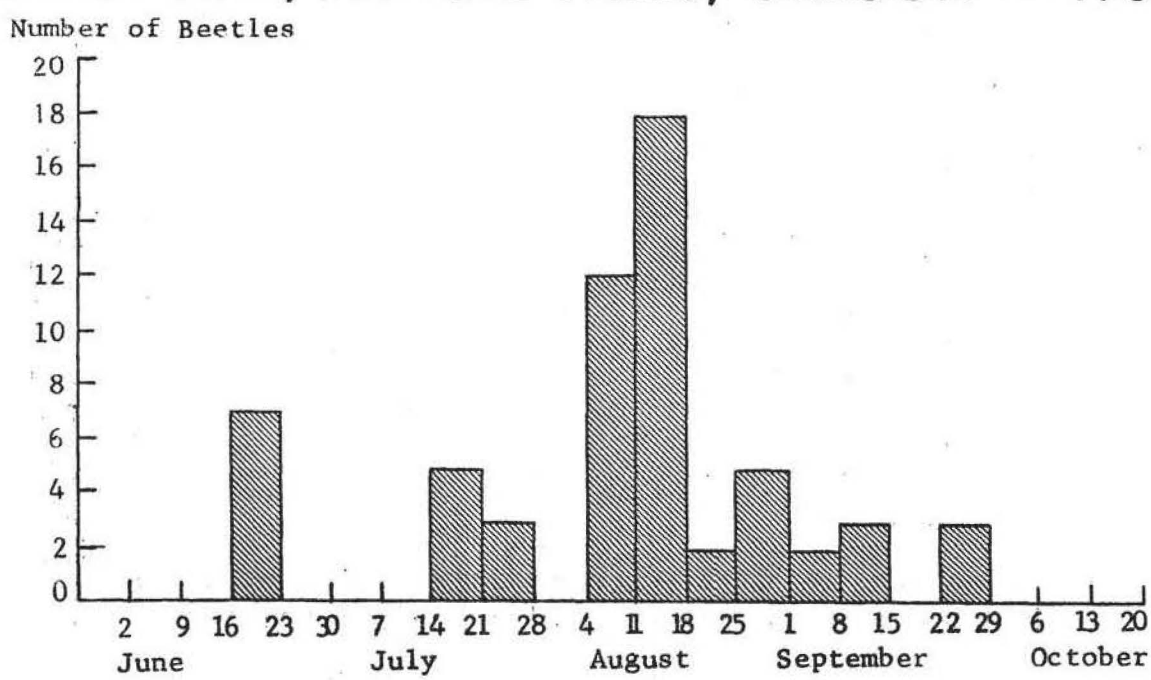
GRAPH 1

APPROXIMATE SEASONAL HISTORY OF MOUNTAIN PINE BEETLE IN PONDEROSA PINE AT PRINGLE FALLS, OREGON — 1963



GRAPH 2

MOUNTAIN PINE BEETLE EMERGENCE FROM CAGED PONDEROSA PINE, PRINGLE FALLS, OREGON — 1963



Approximately one-third to one-half of the parent females successfully passed the winter of 1962-63 and re-emerged in June. Thereafter, their fate was not determined but they did not successfully attack young ponderosa pine in the area. The dense, young stands of ponderosa pine in the study area contain many trees exhibiting large numbers of pitched-out attacks. Perhaps many of those unsuccessful attacks represent the efforts of the parent beetles. Possibly the parents selected other types or species of host material. A fairly large logging operation was underway less than a mile from the study area, and windthrown pines were fairly common throughout the Pringle Falls area. In addition, lodgepole pine was abundant nearby.

Miscellaneous Observations: The influence of cardinal direction and incident insulation on location of attacks and brood survival around the circumference of the bole was profound, particularly where the attacked trees were somewhat exposed to the sun. Attacks were most numerous and brood survival best on the north sides of trees. Rarely was any brood produced on the south side. Although unintentional, the solar-heat method of control was demonstrated at least three times during the season when trees were felled to examine brood development higher on the bole. When the trees were felled to the south, broods on the north side of the tree were exposed to the sun and mortality increased to almost 100 percent in less than a week. In one such tree where the brood had reached the pupal stage at the time of felling, heat-caused mortality was complete before even a single beetle emerged from the upper log surface.

In general, brood productivity in ponderosa pine pole-sized trees was very low in 1963 and probably will be about as low in 1964. Galleries in which no new adults were produced were common. In addition, some galleries were observed in which no egg hatch was apparent. In general, it was uncommon for more than 5 new adults to develop from an attack. On a square-foot basis, emergence was far below the 40-60 beetles per square foot of bark reported for lodgepole pine in the Canadian Rocky Mountains (29), being generally less than 10 beetles per square foot and rarely more. Causes of the low level of brood productivity were not readily apparent. Most mortality occurred in the egg stage or the early larval instars, which might suggest mites or disease, but that such low brood production occurred in practically all attacked trees indicates that young ponderosa pine may be nutritionally unsuitable to mountain pine beetle broods.

At any rate, the question arises as to the sources of D. monticolae infestations in young ponderosa pine stands. Are attacking populations developed within the stands in isolated lodgepole pines or in a rare highly-productive young ponderosa pine? Or do the attacking populations migrate in from infestations in nearby lodgepole pine or mature ponderosa pine stands? The sources of infestation have silvicultural significance; further study to locate them is important.

a good question

Another question of silvicultural significance pertains to the influence of mountain pine beetle activity on species composition of a stand. It is common for the dense young ponderosa pine stands in the Pringle Falls area to be even-aged, except for white fir reproduction as a scattered understory. Does mountain pine beetle killing of the pines favor establishment and growth of the fir? An earlier study by Eaton (11) in stands of more advanced age than those at Pringle Falls indicated that beetle activity can result in complete conversion of a pine stand to fir.

Study Number 2: Silvicultural Relations.

Objective: To locate suitable study sites for long-term investigation of silvicultural relationships of the mountain pine beetle in ponderosa pine.

Method: Study sites were sought throughout the range of ponderosa pine in Washington and Oregon. The minimum size of an area considered was 40 acres. Over the whole of each area, nearly homogeneous conditions of age and stocking were sought, with 50 to 120 years the desired ages (trees average about 6-14" dbh) and heavy to very heavy the desired stocking. An area was considered especially suitable if the mountain pine beetle had been active recently. With respect to species composition, three types of areas were sought: (1) pure ponderosa pine, (2) ponderosa pine mixed with lodgepole pine, and (3) ponderosa pine mixed with true firs or Douglas-fir. All ponderosa pine site classes were to be represented if possible.

To facilitate location of suitable areas, the R-6 Regional Office of the Forest Service asked each national forest on which ponderosa pine occurs to suggest areas which might be suitable for the study. In addition, recent aerial survey maps and reports of insect conditions in the region were examined to locate centers of mountain pine beetle activity. Forest-type maps, which showed species and approximate tree age-size classes were also examined.

Results: All prospective areas had not been examined when this report was prepared; however, three suitable study sites had been located. Their approximate locations are as follows:

Deschutes National Forest: Lookout Mountain
Fremont National Forest: Bauers Creek
Yakima Indian Reservation: Vessey Springs

Visits were also made to the Gifford Pinchot, Mt. Hood, and Malheur National Forests, but no suitable study sites were located. However, because the Gifford Pinchot and Mt. Hood National Forests are among the few containing ponderosa pine in site classes I and II, additional efforts will be made to find suitable study sites in those areas.

Promising areas not yet examined include:

Deschutes National Forest: Fox Butte, Royce Mountain.

Fremont National Forest: Woolley Creek, Sherman Valley.

Ochoco National Forest: Paulina Ranger District.

Okanogan National Forest: Benson Creek, Wolf Creek.

Rogue River National Forest: Jacksonville, Anderson Butte, Cottonwood Glade, Wilcox Peak.

Umatilla National Forest: Peola, Bone Point, Cow Camp.

Wallowa-Whitman National Forest: La Grande, Trail Creek, Frazier Mountain, Wilson Creek.

Wenatchee National Forest: Silver Creek, Table Mountain.

Winema National Forest: Klamath Ranger District.

Warm Springs Indian Reservation: Bald Peter Mountain.

OREGON PINE IPS STUDIES

Background of Problem and Previous Research.

Commenting on the economic importance of the genus Ips, F. P. Keen (19) noted that "With the removal of mature forests, some authorities consider it likely that this group of bark beetles will outrank the *Dendroctonus* beetles in destructiveness to the second crop of pines." In the Pacific Northwest, where more than 60 percent of the ponderosa pine type has been cut over (24) the ips problem is rapidly becoming a matter of concern to forest land managers (Figure 4).

The genus *Ips* is represented by several species in this region, but the Oregon pine ips, *I. oregonis*, is by far the most economically important. This species usually attacks and breeds in dying trees, windfalls, cull logs, and logging and thinning slash. In some years, however, it emerges in great numbers from such materials and then attacks apparently healthy trees, causing top-killing of larger trees and outright killing of young trees in the sapling and pole classes (Figure 5). Probably all species of pine within the beetle's range are attacked (5), but, in the Pacific Northwest, ponderosa pine is the most commercially valuable of the beetle's hosts.

Figure 4. Ponderosa pine killed or top-killed by Ips Oregonis, Wallowa-Whitman National Forest.

Figure 5. Group of ponderosa pine killed by Oregon pine ips, Malheur National Forest.

In the past, the Oregon pine ips problem was largely associated with the buildup of populations in logging slash. More recently, considerable potential has been added to the problem by the initiation of large-scale thinning programs in second-growth ponderosa pine stands in eastern Oregon and eastern Washington. There have been several recent instances, notably those on the Malheur and Wallowa-Whitman National Forests, where slash-bred ips have killed large numbers of residual trees in recently thinned stands. Because such killing represents a sizeable economic loss and sets back forest management plans many years, ways of preventing or reducing the killing have been requested by forest-land managers.

Only two previous studies in the Pacific Northwest have dealt to a significant degree with I. oregonis. Between 1930 and 1932, Beal (2) studied the effect of ponderosa pine logging slash on abundance of the Oregon pine ips and other insects. Buckhorn (4) during the early 1940's studied the relation of the date of logging slash deposition to subsequent tree killing by ips. The biology of the beetle has received practically no study in Oregon and Washington, but a rather detailed investigation was made by Rust (31) in the northern Rocky Mountains during the 1932-1935 period. Additional observations were made on the beetle's biology in the Black Hills by Hauke (16) and others between 1935 and 1937. Terrell (37) studied I. oregonis seasonal history in the northern Rocky Mountains during 1962-1963.

Research elsewhere in the United States on some of the other species of Ips is well advanced and to some extent will serve to guide the present studies of I. oregonis. Struble and Hall (14, 33) studied intensively the biology and ecology of I. confusus in California from 1945 to 1950. More recently, this insect has frequently served as a test animal for Vité (39), Wood (42), Gara (13), and Pitman (25), in their studies on bark beetle host selection. In Canada and the eastern United States, numerous studies have been made on I. pini. Anderson (1) studied its host selection habits in the mid-1940's. During the mid-1950's, Reid (28) studied its slash relations, and Thomas (38) its life history in lodgepole pine. Biological and ecological studies by Schenk (32) in the late 1950's allowed him to develop a tentative classification for red pine susceptible to I. pini attack. In the southern United States, not much research has been done on Ips other than that of Hetrick (17), even though much damage is done by the beetles.

Since the end of World War II, much work has been done in Europe on the host selection habits and population dynamics of the several species of Ips occurring there (6). Results of the European studies are, however, quite unknown to most workers in North America, probably because of the language barrier and poor circulation of the European publications. Needless to say, it is a situation in need of remedy.

Current studies involving Ips, other than that described here, include biotaxonomic studies by Hopping (18), the host selection studies by Vité and fellow workers, and recently initiated studies by Johnson and Schmitz on the bark beetles attacking second-growth conifers in the northern Rocky Mountains.

Broad Study Objectives.

Development of forest management methods of reducing tree mortality caused by the Oregon pine ips is the ultimate objective of these investigations. Necessary for fulfillment of the objective is an understanding of how and why the normally slash-breeding ips sporadically attack and kill standing pines. The investigations will extend over several years because the problem has many facets. The facets investigated will vary from year to year, and, accordingly, each year's objectives will also vary. Following were the objectives for 1963:

1. To become familiar with the problem.

2. To initiate a seasonal history study of the beetle in central Oregon.

3. To investigate the influence of sex ratio on attack habits and brood productivity.

4. To investigate the relation of host condition to the beetle's capacity to overcome trees.

1963 Studies.

Study Number 1: Seasonal History in Central Oregon.

Objective: To determine the seasonal history of *Ips oregonis* in thinning slash in several central Oregon localities during 1963.

Methods: Caged rearings and periodic field observations were made in each of the following areas:

Hehe Butte, Warm Springs Indian Reservation
(Elevation 3,000 ft.)

Pringle Falls, Deschutes National Forest
(Elevation 4,300 ft.)

Cove Springs, Malheur National Forest
(Elevation 4,800 ft.)

Wildhorse Creek, Fremont National Forest
(Elevation 5,300 ft.)

In early April bark dissections were made in the Pringle Falls area of slash infested in the early fall of 1962, and duff was collected from beneath the same slash and placed in rearing cages in Portland to determine the overwintering sites and stages of *I. oregonis.*

Field examinations were made in all areas during the remainder of April and in early May to determine the periods when the first 1963 attacks were made by overwintered adults. Subsequent to those attacks,

bark dissections of infested slash were made throughout the season to follow seasonal history progress. Caged rearings of infested slash were initiated in early June in all areas. Assistance in maintaining the rearings at Cove Springs was given by National Forest Administration on the Burns District, Malheur National Forest, and at Wildhorse Creek by personnel of the Drews Valley District, Fremont National Forest.

Results: The Oregon pine ips passed the winter of 1962-63 in the adult stage in duff almost immediately beneath the logs infested at the end of the 1962 flight season. Bark dissections made on April 5, 1963 in the Pringle Falls area failed to reveal any live adults beneath the bark of logs which contained brood the previous October. A rearing of approximately 1/2 cubic foot of duff collected from immediately beneath the logs produced 203 adults. A similar rearing of duff collected about 3 feet away from the same logs produced only 11 beetles.

Between-area differences in seasonal history, which were distinctly related to area elevation, were first exhibited in dates of peak attacks by overwintered adults (Table 1). At Hehe Butte, the earliest attacks occurred shortly after May 10 and became common by May 15. At Pringle Falls, attacks were common by May 20. At about that date attacks began in the Cove Springs area and were common by the end of the month. Most attacks in the Wildhorse Creek area occurred in early June.

The overwintered parent adults re-emerged from the initially attacked logs and proceeded to establish second broods at about the time their first broods reached the pupal stage. Second attacks were begun in the Hehe Butte area during mid-June. In the Pringle Falls area the same event occurred in late June, at Cove Springs during early July, and at Wildhorse Creek during late July.

Although some individuals of the first generation attained the adult stage shortly after June 15 in the Hehe Butte area, the first generation did not begin emerging until about July 10, with peak emergence about July 15. The pre-emergence period was similarly long in other areas, and peak emergence of the first generation occurred during the last two weeks of July at Pringle Falls, during late July and early August at Cove Springs, and about the middle of August at Wildhorse Creek.

Second brood established by overwintered adults emerged in early August at Hehe Butte, about the middle of August at Pringle Falls, and in late August at Cove Springs. Some emergence of the second brood occurred in early September at Wildhorse Creek, but most were still in the brood logs when the last observation was made in that area on December 18.

Table 1. Approximate Oregon Pine Ips Flight Periods in Central Oregon, 1963.[1/]
(based on field observations)

Locality (Elevation)	OW 1-att.	OW 2-att.	gen.I brd.A 1-att.	gen.I brd.B 1-att.	OW 3-att.	gen.I brd.A 2-att.	gen.I brd.B 2-att.	gen.II brd.A 1-att.	gen.II brd.B 1-att.	OW 4-att.	gen.III 1-att
Hehe Butte (3,000')	May 10-May 25	Jun.15-Jun.30	Jul.10-Jul.30	Jul.25-Aug.20	Mid-Jul.	Aug.10-Aug.30	?late Aug.-early Sep.	Sep.5-15 (partial)	DNO	?mid-Aug.-early Sep.	DNM
Pringle Falls (4,300')	May 15-May 30	Jun.20-Jul.5	Jul.15-Aug.5	Aug.1-Aug.25	Late Jul.	Aug.20-Sep.10	?early Sep.	DNO	DNO	?late Aug.-early Sep.	NE
Cove Springs (4,800')	May 20-Jun.5	Jun.25-Jul.10	Jul.25-Aug.10	Aug.5-Aug.30	Late Jul.-early Aug.	?early Sep.	DNO	DNO	DNO	?early Sep.	NE
Wildhorse Creek (5,300')	May 25-Jun.10	Jul.1-Jul.20	Aug.5-Aug.20	DNO	DNO	DNO	NE	DNO	NE	DNO	NE

1/ Table abbreviations:

OW = overwintered adults
gen. = generation
brd. = brood
DNO = emergence or re-emergence did not occur.
DNM = some brood established but did not mature.
NE = previous attacks necessary to this event did not occur.

The re-emergence of parent adults was a prominent feature of the I. *oregonis* seasonal history in all areas. The re-emergence habit allowed many overwintered adults to make second and third attacks, and some to make fourth attacks, during the 1963 season. The percentage of parents re-emerging after brood establishment usually exceeded 50 percent.

Many of the third and fourth attacks by parent beetles, and to a lesser degree the second attacks, resulted in practically no brood being produced because attack densities generally were so high that very little cambium was left in which broods might develop. The number of beetles involved in such attacks exceeded 200 beetles per square foot, and sometimes more than 400 per square foot. Attacks of a similar nature by other species of *Ips* have been observed and have been termed "feeding" attacks (36).

It will be shown later in this report, under studies on *I. oregonis* sex ratios, that the "feeding", or very high density, attacks were distinguished by the presence of a higher ratio of males than were involved in normal attacks. The usual attack ratio was about 3 females per male, but the sex ratio in the "feeding" attacks was about 1.5 females per male. This makes it difficult to associate the "feeding" attacks with re-emerged parent adults because they are believed to be mostly females; however, such attacks were usually begun during periods when the flight population was composed principally of parent beetles. In regard to this discrepancy, it was observed that attack densities in the "feeding" attacks were about the usual 3 females per male during the first two weeks that such a log was under attack. Then, sometime about the third week there was a heavy influx of attacking beetles, and the attack became a "feeding" attack. Apparently it was during the second phase of the attack that male beetles were attracted in great numbers. This too is an apparent discrepancy, for most beetles usually involved in the later attack phases are females. There is much room for speculation in this matter, which emphasizes the need for further study.

Logs and trees with high density ips attacks usually showed evidence of woodpecker activity. In fact, woodpecker work frequently gave evidence of attack before it was indicated by facing of the tree. The bark, particularly in the mid- and upper-crown, was often stripped from much of the bole by the combination of beetle and woodpecker activity. Importance of woodpeckers as natural control agents was not assessed, but it did not appear to approach the 90 percent level as Graham (14) found for woodpeckers preying on *I. pini* in standing jack pine.

At Hehe Butte some first generation adults re-emerged during late August and early September and established second broods. Much of this brood matured in late November, but that which had not reached the adult stage by mid-November died, presumably from freezing.

First adults of the second generation appeared shortly after mid-August at Hehe Butte, about September 1 at Pringle Falls, and approximately mid-September at Cove Springs. Some of the second generation at Wildhorse Creek reached the adult stage in late September and early October, but much of it had not completed development by the time winter set in and were killed by low temperatures. Consequently, an incomplete second generation was developed.

Although a few second generation adults emerged and laid eggs in early September at Hehe Butte, a partial third generation did not develop because of poor egg hatch, and because brood from the few eggs that did hatch suffered almost complete mortality due to low temperatures before reaching the adult stage. Another reason for failure of brood development in attacks made late in the season was that the attacks were usually made in older slash apparently too dry to permit brood development.

When last observed on December 18, no significant numbers of beetles, if any, had abandoned the logs to seek overwintering sites in the duff. Populations entering the overwintering period included representatives of all 1963 broods, and probably some beetles which had successfully passed the previous winter.

For the most part the seasonal history of the Oregon pine ips during 1963 was determined by field observations because the caged rearings, except at Pringle Falls, were unsuccessful. Few beetles were collected from screen cages at Hehe Butte, Cove Springs, and Wildhorse Creek, primarily because matured beetles seemed to prefer remaining in brood logs rather than roaming about the cages. Terrell (37) experienced similar difficulty in rearing _I. oregonis_ during 1962. He attributed rearing failure to poor vigor of caged broods. He obtained better results in 1963 by caging infested logs just prior to brood emergence.

Emergence in screen cages at Pringle Falls was similarly poor, but rearings in cardboard cages were quite productive (Figure 6 and Graph 3), and were useful in timing seasonal history observations.

Because emergence of the first generation occurred about a week earlier in the cardboard cages than in the field, temperatures in the cardboard cages were measured for a week in early August. It was found that at mid-day, temperatures in the cages were usually at least 10 degrees higher than air temperatures. In addition to offering an explanation of the earlier emergence of the first generation, the higher temperatures in the cages may also explain why the second generation in the cages emerged during September and October, whereas in the field the second generation was still in brood logs on December 18.

The seasonal history of the Oregon pine ips was closely followed in the Pringle Falls area (Graph 4). Particularly intensive observations were made during the development of the first generation. The information shown in Table 2 was gained on the duration of certain events.

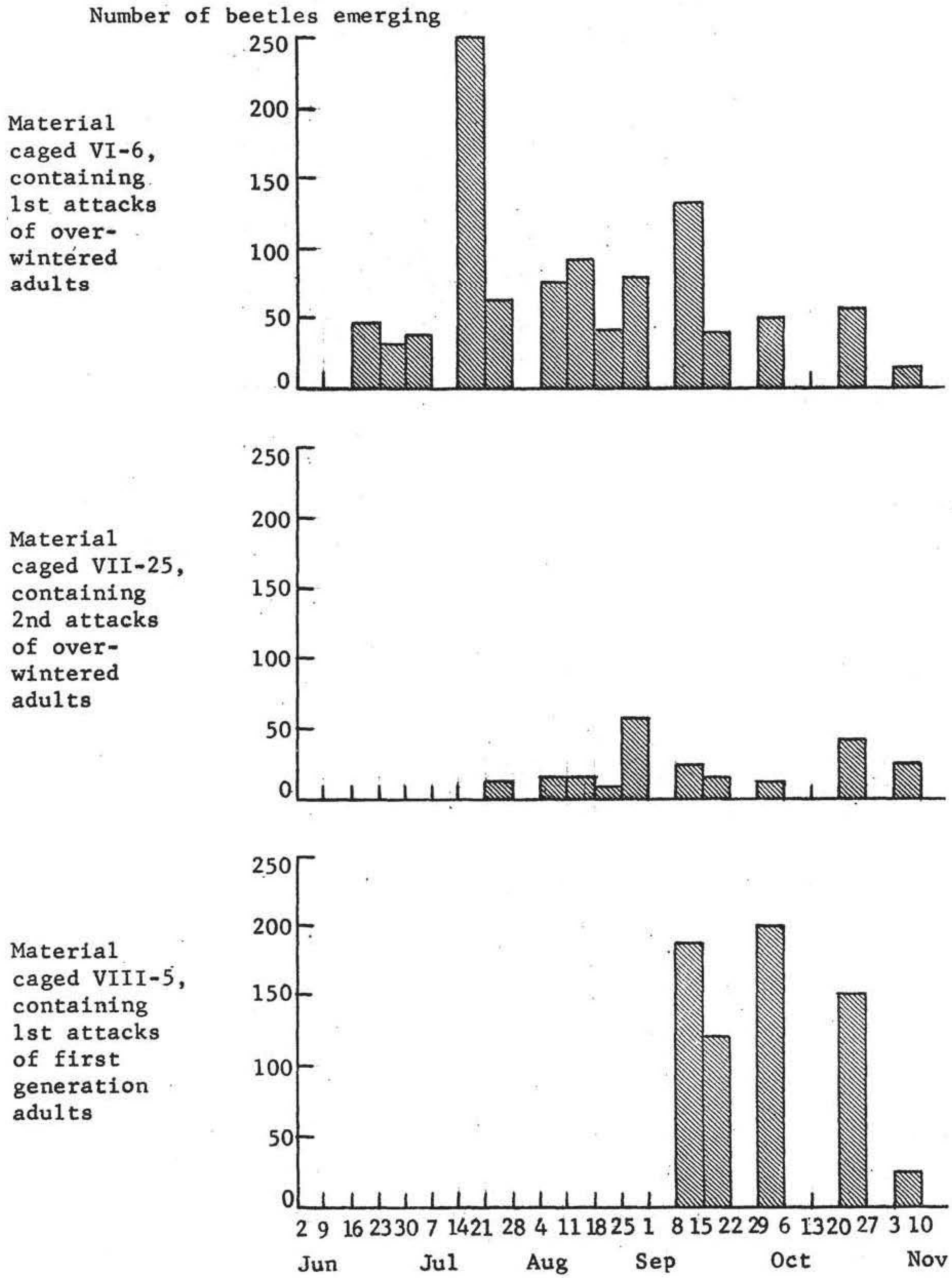
Figure 6. Cardboard cage used in seasonal history rearings.

Table 2. The duration of certain seasonal history events in the first generation of the Oregon pine ips at Pringle Falls, 1963.

Event	Duration
Attack to initiation of egg laying	2 days
Incubation of eggs	10 days
Instar I	1 to 2 days
Instar II	4 to 5 days
Instar III	6 to 8 days
Instar IV	8 to 10 days
Pupal stage	4 to 5 days
Pre-emergent new adult stage	15 to 21 days
Attack to emergence	50 to 60 days

GRAPH 3

OREGON PINE IPS EMERGENCE FROM CAGES, PRINGLE FALLS, OREGON — 1963



The season of Oregon pine ips flight activity in the Pringle Falls area began about May 15 and continued until about September 15. Generally, as indicated by Graph 4, flight activity occurred during that portion of the year when daily maximum temperatures were substantially above 60 degrees F (Graph 5). Temperatures were warm enough for flight during late September and early October, but none occurred. A possible explanation is that the rapid depression of temperatures between September 10 and 15 had stimulated the beetles to begin preparation for the coming winter.

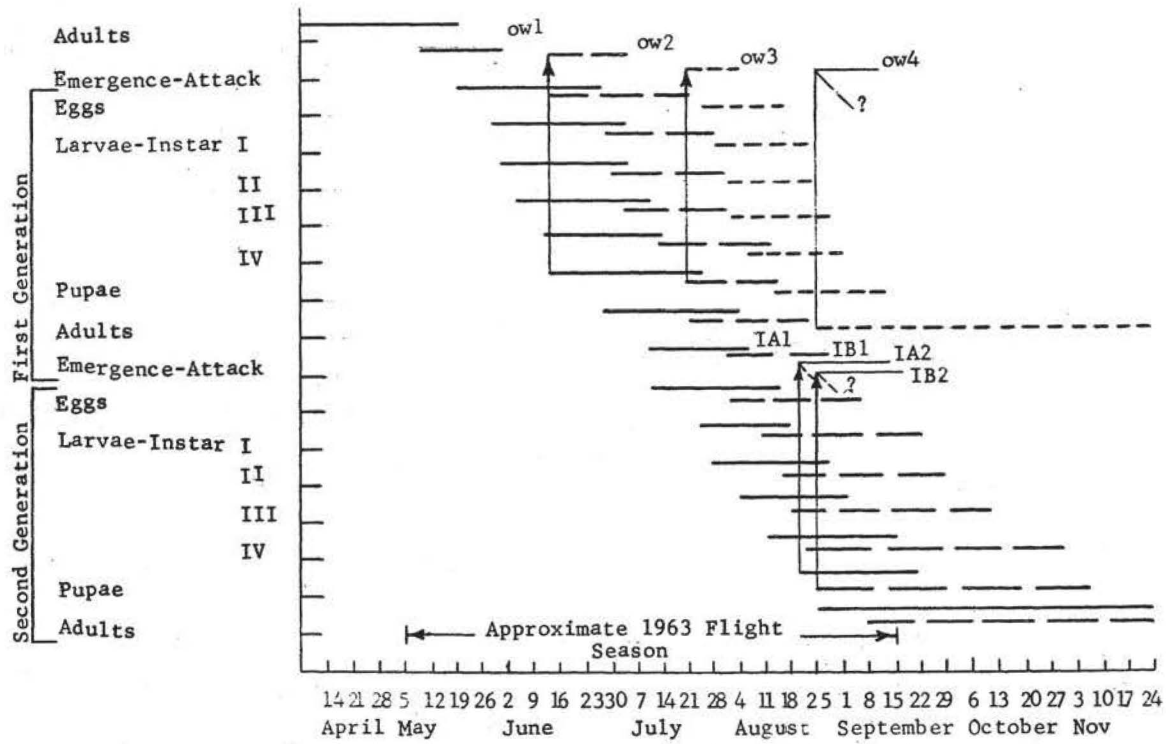
An observation was made in December 1963 which may give some indication of the probable character of the population which will survive the winter of 1963-64 in the Pringle Falls area. More than 4 inches of rain fell during November. It had no observed effect on the subcortical environment in logs containing new adults that were developed late in the season. But in the logs where attack densities were extremely high, and which apparently contained that segment of the beetle population most capable of killing trees, the subcortical environment was saturated with water. It would seem that the effects of cold winter temperatures would be more severe in the heavily attacked logs, because the freezing of the free water beneath the bark might result in mechanical damage, and death, to the beetles. This would have the implication that the segment of the population most capable of killing trees would be greatly reduced by overwintering mortality.

Another general observation which may be important in planning future studies of the Oregon pine ips is that recent levels of ips killing have been higher in some areas than others. In Oregon, the Oregon pine ips has been much more of a problem during the last 10 years on the Umatilla, Wallowa-Whitman, Malheur, and Ochoco National Forests than it has been in the forests on the east slope of the Cascades.[3/] During the 1963 season, recent radial growth was examined in two areas: (1) Malheur National Forest, on which the Oregon pine ips has killed many trees in recent years, and (2) Deschutes National Forest, on which the insect has killed few trees in the same period. By counting the number of annual rings in the last inch of radial growth, it was found there were about 20 rings to the last inch of growth on the Malheur, while in the Deschutes there were only about 10. This suggests numerous explanations as to why ips killing frequently follows thinning on the Malheur, but seldom does on the Deschutes. First, it suggests that ips killing may be greatest on the lower sites. Second, it suggests that the ips hazard may be higher in stands growing on certain types of soils. Third, it suggests that ips killing is more likely to follow thinning if growth in thinned stand was stagnated for a lengthy period prior to thinning.

3/ Orr, P. W. 1963. Generalized areas of Oregon pine ips outbreaks, 1950-1962. U. S. Forest Service, Div. Timber Mngt., Insect and Disease Control Branch, Portland, Oreg., 1 map.

GRAPH 4

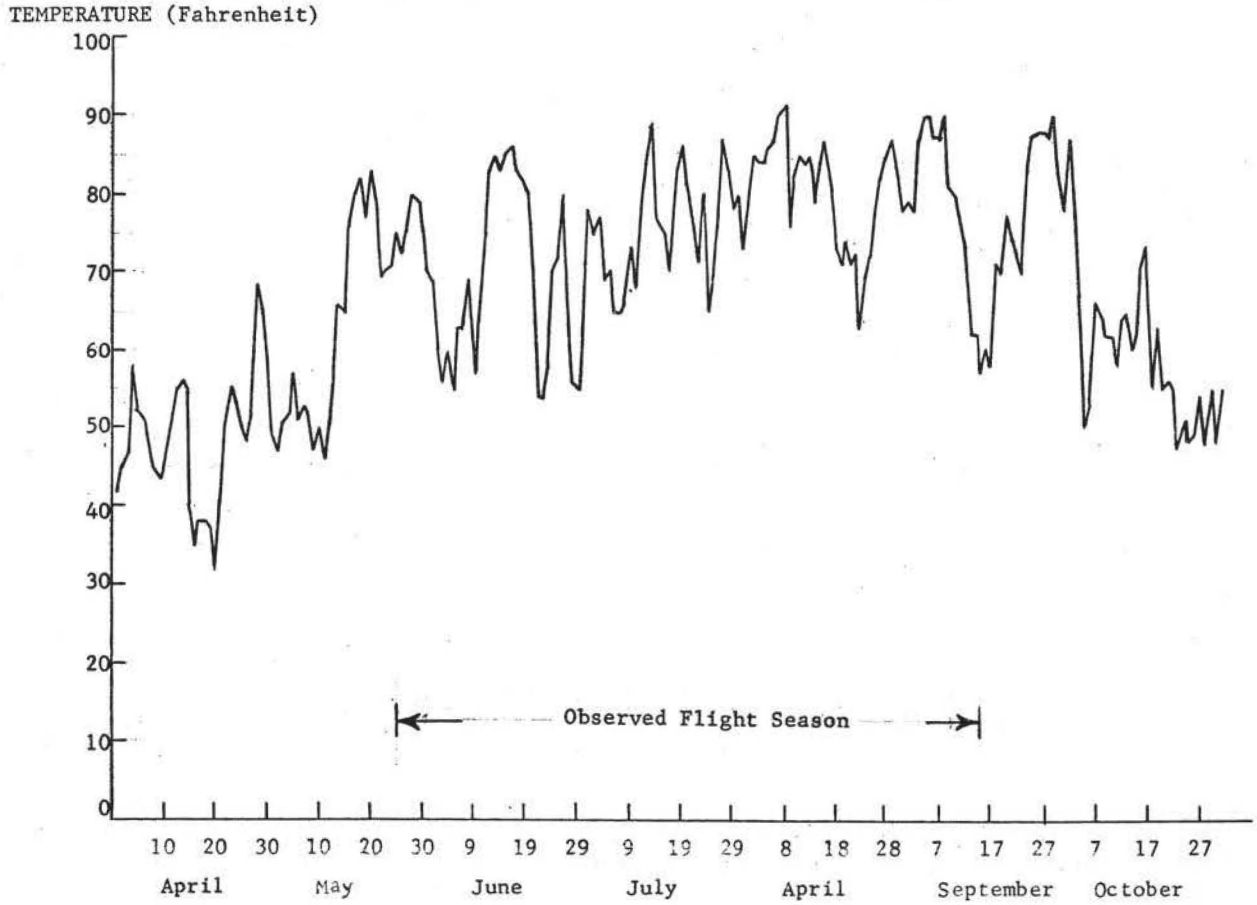
APPROXIMATE SEASONAL HISTORY OF OREGON PINE IPS, PRINGLE FALLS, OREGON — 1963



Note: The complexity of this graph serves to illustrate two features of the Oregon pine ips seasonal history 1. Ips flight periods are nearly continuous during the flight season. 2. Examination of infested material during flight season will likely reveal the presence of any or all life stages.

GRAPH 5

DAILY MAXIMUM TEMPERATURES, WICKIUP DAM, AS CORRELATED WITH IPS OREGONI FLIGHT — 1963



<u>Study Number 2: Influence of Sex Ratio on Attack Behavior and Brood Productivity</u>.

<u>Objectives</u>:

A. To develop a reliable method for sexing *Ips oregonis*.

B. To determine sex ratios in wild populations of *I. oregonis* at various points in the beetle's seasonal history.

C. To determine the influence of sex ratio on attack habits of caged *I. oregonis* populations.

D. To determine the influence of sex ratio on brood productivity of caged *I. oregonis* populations.

<u>Methods</u>:

Except for some field observations in the Hehe Butte, Cove Springs, and Wildhorse Creek areas, this study was conducted at the Pringle Falls field station.

The third declivital spine and the frontal knob were tested for their reliability as indicators of sex. Shape and length of the spine and presence or absence of the knob were compared with presence or absence of the stridulatory organ.

The sex ratios in the main flights of wild *I. oregonis* populations in the Pringle Falls area were determined by use of beetle dimorphic sex characters. Gallery patterns in trees killed during 1962 and 1963 in the Cove Springs area were examined for information as to the sex ratio of the ips population which had attacked the trees.

To gain information on the influence of sex ratio on attack habits a sleeve cage enclosing approximately 3 square feet of bark surface was placed near breast height on each of 12 living ponderosa pines. The trees ranged in size from about 5 to 7 inches dbh. On August 14, the following ips populations of 100 beetles each were introduced into the 12 cages:

Unmated or pre-emergent new adults, with sex ratios of 1 female: 1 male, 3:1, 9:1, 24:1, 99:1, 100:0.

Mated or parent adults, with sex ratios as above.

The trees were felled on November 7, and fate of the beetles and trees determined.

The influence of sex ratio on brood productivity was investigated by introducing ips populations into 12 cardboard cages, each containing freshly cut ponderosa pine bolts with approximately 3 square feet of bark surface. 100 new adults were introduced into each of

6 cages on July 18, and 100 parent adults into each of the other 6 cages on July 28. Sex ratios used were the same as above. Total number of beetles emerging from each cage was recorded. After completion of emergence, the bark was removed from the test bolts and the character of parent and larval galleries determined.

Results:

Methods of sexing beetles - Examination of 100 beetles showed the frontal knob was not a consistent dimorphic secondary sex characteristic in the Oregon pine ips. Unlike I. confusus in which Lyon (21) found that a protuberance on the frons distinguishes the male of the species, I. oregonis does not show the same consistency. While all 52 males examined had a protuberance of some kind on the frons, 17 of 48 females examined also had a definite protuberance.

In 1935 Rust (31) made the observation that the male Oregon pine ips could be distinguished from the female by the shape of the third declivital spine. The reliability of this character was tested on 1000 beetles during 1963, by comparing shape of the spine with presence or absence of the stridulatory organ. Where at least one third spine was intact, sexing reliability was 100 percent. However, because 17 of the examined beetles had both third spines broken, overall sexing accuracy was just over 98 percent. Although using shape of the third spine is slightly less accurate than determining sex by presence or absence of the stridulatory organ, on the average it is probably three or four times faster. Furthermore, because less manipulation of a beetle is involved, chances for injury to the beetle are less.

The third declivital spine of the male is approximately 1-1/2 to 2 times as long as the second spine; whereas, the third spine of the female is about the same length as the second (Figure 7). Additionally, the third spine of the male is somewhat bent and blunted distally, while in the female it is straight and pointed.

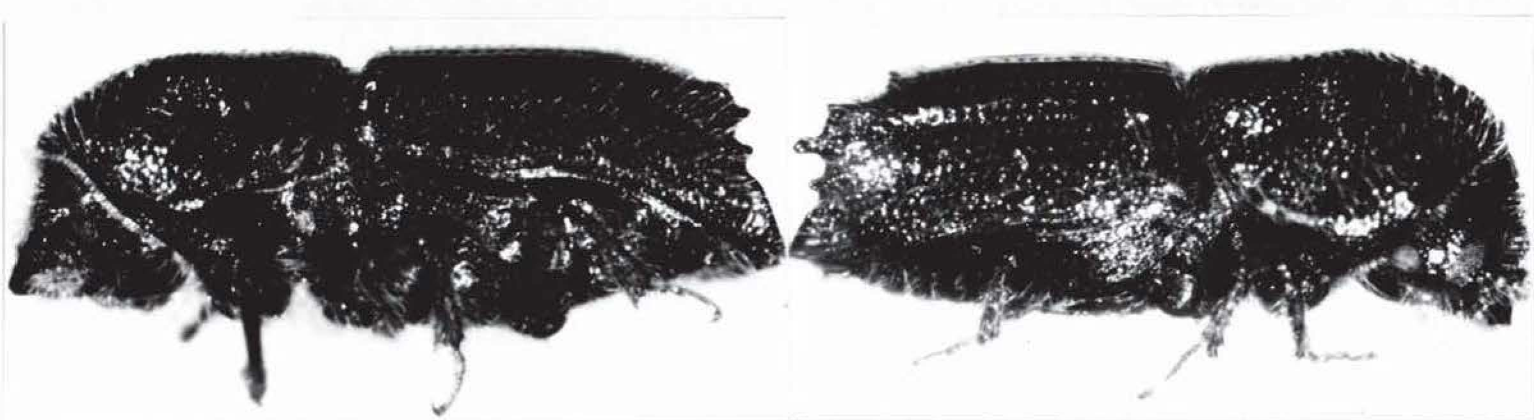


Figure 7. Side views of Oregon pine ips female (left and male (right).

Sex ratios in wild populations - Sex ratios at various points in the ips seasonal history at Pringle Falls, determined through use of the shape of the third declivital spine, were as shown in Table 3.

Table 3. Sex ratios in wild Oregon pine ips populations at Pringle Falls, 1963.

Point in Seasonal History	Total Examined	Females	Males	Sex Ratio
Overwintered beetles in duff	193	116	87	1.3:1.0
Overwintered beetles at attack	497	347	150	2.3:1.0
First generation prior to emergence	3,330	1,574	1,726	.9:1.0
First generation at attack	2,068	1,523	545	2.8:1.0
Beetles in logs prior to over-wintering	1,000	583	417	1.4:1.0

It is believed the attack sex ratio shown here for overwintered beetles at attack is lower than the actual because it was determined before the end of the attack period. The difference in sex ratios prior to emergence for the first generation and second generation (in the table: beetles in logs prior to over-wintering) is probably due to the presence of some parent adults in the second generation samples. Parent adults were not present in the first generation samples because they had abandoned the brood logs prior to brood maturation. At the comparable point in the history of the second generation, weather conditions were not as conducive to flight. As a result, many parent beetles which established the second generation entered the over-wintering period in the logs with their broods.

Considerable between-sample variability was noted in attack sex ratios. For instance, in sexing lots of 100 beetles from various logs, sex ratio in a series of logs attacked in late July varied from 1.2 to 5.7 females per 1 male. The higher extreme did not seem too unlikely under rules of chance, but the lower extreme was unexpected, for in terms of numbers of beetles of each sex involved it represented a greater departure from the usual attack sex ratio of approximately 3:1. Furthermore, the low attack sex ratios were usually typical of logs in which attack densities were so heavy and the cambial tissues so completely devoured that

little, if any, brood was produced. It seemed that additional data was needed; therefore, beetle samples were collected from 8 very heavily attacked logs and sex ratio determined for each log's population.

Table 4. Attack sex ratios of the Oregon pine ips in very heavily attacked logs.

Log	Females	Males	Sex Ratio
1	193	119	1.6:1.0
2	143	104	1.4:1.0
3	97	70	1.4:1.0
4	161	120	1.3:1.0
5	100	81	1.2:1.0
6	180	122	1.5:1.0
7	165	98	1.7:1.0
8	161	98	1.6:1.0
	1,200	812	1.5:1.0

It is considered important that examinations of some 20 trees killed by *I. oregonis* in 1962 and nearly 100 trees killed in 1963 all showed the same almost complete destruction of the cambial tissues. When the 1963 killed trees were examined soon after they had begun to fade in mid-August the beetles had already abandoned them. Because no beetles were in the trees and because the gallery patterns had been destroyed by beetle activity, it was impossible to determine sex ratios of the beetles which attacked the standing trees. It is believed, however, that they were similar to those in the slash logs where attacking beetles behaved in a like manner--that is, approximately 1.5 females per male.

This apparently significant departure from the usual attack sex ratio has the effect of concentrating male beetles. It is considered probable that this concentration of males increases the capacity of ips to overcome living trees. Why it occurs is not known. That attacks of this kind seemed to occur most commonly during the times of parent re-emergence appears to be inconsistent with the high number of males involved in the attacks--because most re-emerged parents are believed to be females. At any rate, further investigations will be made in 1964 in an effort to gain an understanding of why and how such attacks occur, for therein may be the clue to why and how the Oregon pine ips attacks and kills standing trees.

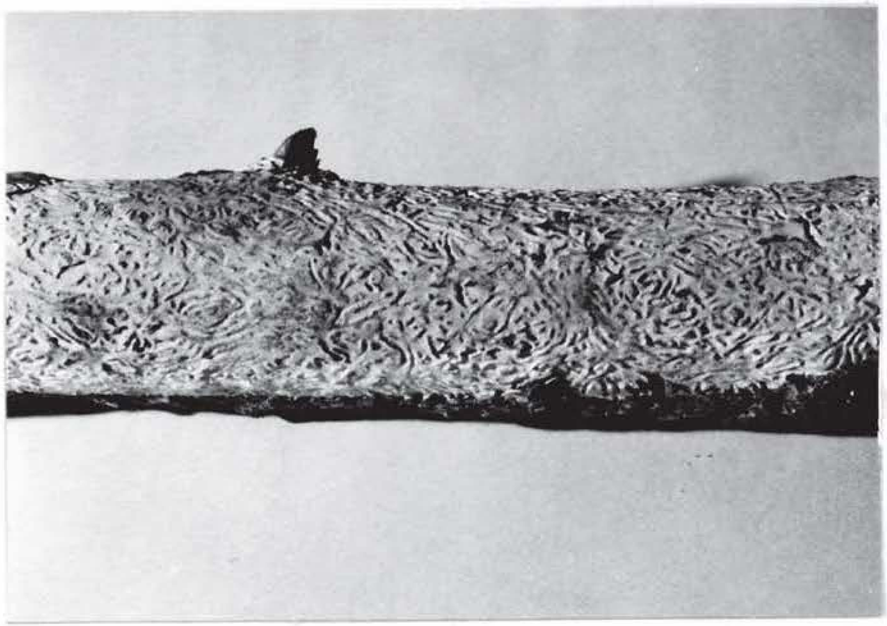


Figure 8. Ponderosa pine thinning slash log which was very heavily attacked by Oregon pine ips but which produced no brood. Note deep etching of the wood.

<u>Influence of sex ratio on attack behavior</u> - The cagings on live trees to investigate the influence of sex ratio on ips attack habits were unsuccessful. Many of the caged beetles attempted attacks, but none were successful (Table 5). As soon as they reached the cambium, pitch flowed into their tunnels, entrapping and killing them.

Table 5. Influence of sex ratio on attack habits of the Oregon pine ips.

Kind of beetles	Sex ratio	No. introduced	No. successful attacks	No. unsuccessful attacks
New	1:1	100	0	8
New	3:1	100	0	7
New	9:1	100	0	8
New	24:1	100	0	22
New	99:1	100	0	19
New	100:0	100	0	18
Parent	1:1	100	0	25
Parent	3:1	100	0	16
Parent	9:1	100	0	19
Parent	24:1	100	0	13
Parent	99:1	100	0	26
Parent	100:0	100	0	18

Several explanations are possible for the failure of these cagings. The most probable are: (1) Insufficient numbers of beetles were used, and (2) the trees were much too vigorous for even a larger number of beetles to overcome. Furthermore, most of the caged beetles were females. Observations made in another phase of this study suggest that concentration of male beetles is a more important factor in ips outbreaks than concentration of females. Still, because attacks on standing trees seemed to be most common during parent adult emergence, a need exists for additional investigations on the attack habits of parent adults to determine if they differ with those of new adults.

Influence of sex ratio on brood productivity - Inconclusive results were obtained from the cagings designed to investigate the influence of sex ratio on brood productivity. Of the 6 cages in which new, unmated beetles were introduced, broods were produced only at sex ratios 1:1, 3:1, and 9:1. But because those broods were very small, and because fewer beetles were obtained from the 1:1 rearing than were introduced into the cage, the meaning of these results is not clear. It could be that many of the introduced new adults were sexually immature when caged and were not able to mature under the conditions in which they were placed. Overall, these results may suggest that *I. oregonis* does not mature sexually until after emergence and that mating does not occur among new adults prior to their emergence, but certainly a definite conclusion can not be made to that effect.

The parent adult rearings were much more productive; however, because caged material was unintentionally exposed for three days to the wild population, it is probable that the material was already lightly infested with ips when caged. Accordingly, the validity of the results obtained is in doubt. They are recorded here, along with data on the new adult rearings, largely as a matter of record (Table 6).

Table 6. Influence of sex ratio on brood productivity of the Oregon pine ips

Kind of beetles	Sex ratio	Beetles introduced	Beetles emerged*	Beetles produced
New	1:1	100	92	- 8
New	3:1	100	151	51
New	9:1	100	124	24
New	24:1	100	48	- 52
New	99:1	100	78	- 22
New	100:0	100	67	- 33
Parent	1:1	100	201	101
Parent	3:1	100	478	378
Parent	9:1	100	564	464
Parent	24:1	100	261	161
Parent	99:1	100	322	222
Parent	100:0	100	135	35

* Including dead beetles collected from inside cage and under bark.

Study Number 3: Tree Physiological Condition; Success of Forced Attacks

Objectives:

A. To investigate the relationship of radial growth and oleoresin exudation pressure in ponderosa pine to time of season and soil moisture levels.

B. To determine if success of forced *Ips oregonis* attacks on ponderosa pine is related to seasonal changes in tree physiological condition.

Methods:

This study was conducted on the Pringle Falls Experimental Forest. Aluminum band dendrometers were installed July 3 on 9 ponderosa pines (Figure 9). The trees selected were either dominants or co-dominants, approximately 6 inches d.b.h., about 40 years in age, and showed no serious crown or stem defects. The trees were all located within a heavily stocked stand, and all within an area about 100 feet long by 50 feet wide. Measurements were made at two-week intervals through July and August, and once each month from September through December. Because the bands were installed after radial growth had begun, increment cores were taken on December 17 to determine total radial growth for 1963.

It was planned to use pressure gages for measuring oleoresin exudation pressure throughout the growing season; however, the gages could not be obtained until early August. Still, gages were installed in trees during August and September to become familiar with techniques.

It had also been planned to take soil moisture measurements in the study area and correlate them with oleoresin exudation pressure measurements. However, none were made because of the aforementioned late delivery of the pressure gages, and because the Bend Silviculture Laboratory made weekly soil moisture measurements at a site less than 1/2-mile from the study. These data were made available to the project.

Oregon pine ips attacks were forced on 10 different ponderosa pines on each of the following dates: July 1, July 22, and August 15. On each tree 10 forced attacks were made by driving a nail into the bark, placing a single male beetle in the nail hole, and then stapling a piece of fine-mesh plastic screen over the hole. About two weeks following the forcing of attacks, the fates of the beetles and trees were determined.

Results:

Relationship of radial growth and oleoresin exudation pressure to time of season and soil moisture levels - There was considerable variation between trees in the seasonal period of radial growth during 1963. At the extremes of variation, 5 trees completed their seasonal radial growth in late July and early August, while 1 tree did not complete its growth until after the middle of September. The following table shows approximate dates when 90 percent and 100 percent of seasonal radial growth was completed in each of the 9 trees:

Table 7. Differences in seasonal period of radial growth in 9 young ponderosa pines, Pringle Falls, 1963.

Tree no.	Circumference increase Before July 3	Circumference increase After July 3	Growth percent and approximate date completed 90%	Growth percent and approximate date completed 100%
	-- inches --			
1	.33	.04	early July	mid-August
2	.25	.08	early August	late August
3	.17	.02	early July	early August
4	.10	.01	early July	early August
5	.19	.02	early July	early August
6	.35	.04	early July	mid-August
7	.10	.13	early Sept.	late Sept.
8	.26	.08	mid-August	mid-Sept.
9	.43	.07	late July	early Sept.

Because the dendrometer bands were scribed to measure circumference increase only to the tenth-inch, the accuracy of the growth measurements was necessarily limited, and, therefore, allow only these conservative conclusions.

1. Seasonal period of radial growth varied considerably between some trees.

2. Trees showing comparable seasonal increases in circumference did not always grow at similar rates or during the same period.

An additional observation of consequence is that when the last measurements were made on December 4 the dendrometers indicated a decrease in the circumferences between then and October 25 in all but two trees. This probably resulted from constriction of the trunks due to the cold temperatures in late November and early December.

Figure 9. Aluminum band dendrometer used in measuring seasonal progress of ponderosa pine radial growth.

Considerable difficulty was experienced in securing oleoresin exudation pressure determinations because of insufficient resin flow. Of more than 30 trees, ranging 5 inches to 32 inches d.b.h., only one exuded enough resin to activate a pressure gage. Measurements of oleoresin are planned for 1964, and, among other changes in technique, glycerin will be placed in the gages and their fittings as recommended by Vité (39) whenever abundant resin is not produced.

Soil moisture data for the Pringle Falls Experimental Forest that was made available by the Bend Silviculture Laboratory showed that soil moisture did not become limiting at any time to ponderosa pine during the 1963 season. Moisture levels were so high that a significant difference between those under thinned and unthinned stands did not occur.

Success of forced Oregon pine ips attacks - All 300 forced ips attacks were unsuccessful, and none of the 30 trees were killed. 82 percent of the beetles were captured in pitch. 4 percent of the beetles died without coming in contact with pitch, either being mortally wounded in handling, or apparently being overcome by volatile chemicals in the bark. The remaining 14 percent of the beetles cut holes in the plastic screen and escaped. Almost invariably, such beetles had burrowed considerably in the bark and cambial tissues before effecting their escape.

knock the tops off the population

The total lack of success with the forced attacks suggests that I. *oregonis* is unable to overcome healthy trees when attack densities are light. Future plans are to use much greater numbers of beetles per tree in making forced attacks. Additionally, because the technique of placing a beetle in a hole covered with plastic screen (Figure 10) is so time consuming, plans are to force attacks by pinning half of a gelatin capsule over a beetle.

Figure 10. Examining forced attacks of the Oregon pine ips on a young ponderosa pine.

MISCELLANEOUS STUDIES AND OBSERVATIONS

Because other 1963 studies of higher priority consumed more time than had been expected, very little attention was given to planned miscellaneous activities. For the most part, time was available only for cursory observation and limited testing.

1. Bark Beetles in Windthrown Ponderosa Pine and Lodgepole Pine

   Cursory observations revealed the Oregon pine ips and the red turpentine beetle as the bark beetles most frequently attacking windthrown pines in the Pringle Falls area in 1963. In some windthrows the western pine beetle was common; in others it was almost absent. The mountain pine beetle was not common, and where it was found, its galleries were noted only on the undersides of the fallen trees. Flatheads were frequently found on the uppersides of the downed trees.

2. Use of "Tanglefoot" to Capture Bark Beetles

   A limited test was conducted to determine if "Tanglefoot" would capture and retain bark beetles. The material was spread generously on 20 pieces of cardboard about 4 inches square. Then, 25 Oregon pine ips were dropped onto the center of each of the "Tanglefoot"-covered pieces of cardboard. Ten of the cards were nailed on a tree in the open at Pringle Falls; the other 10 cards were placed in the insectary.

   Two weeks later these general observations were made:

   a. Most of the cards placed outdoors had accumulated a large amount of debris, including other insects, needles, cone scales, etc. Yet, they retained almost all of the beetles which had been placed on them.

   b. The indoor cards still held most beetles, but a few had worked their way through the "Tanglefoot" and off the card.

   It was concluded that "Tanglefoot" would satisfactorily retain most bark beetles which might alight on it, but that larger pieces of cardboard should be used to reduce the number of beetles working their way off the card.

3. Chipped Slash as a Source of Attraction for the Oregon Pine Ips.

   Frequent but only cursory observations were made of fresh chipped slash to determine if it served to attract ips or other bark beetles. No attraction of ips was observed either to the chipped slash or to nearby standing trees. However, on the Malheur National Forest, the only area studied in 1963 in which significant ips-killing occurred, some trees were killed in "chipper-strips". The areas had been thinned and the slash chipped in late June and early July.

Because the date of the attacks was not definitely known, it was not clear whether they occurred before or after the chipping of the slash.

4. Use of Spray-Paints to Mark Bark Beetles

The only spray-paint tested in 1963 was the type usually used in marking trees. It was quickly found unsatisfactory because it dried slowly, readily allowing painted beetles to stick to each other, to the surface on which they were when painted, and to those to which they were transferred after being painted.

5. The Red Turpentine Beetle in Thinned Pine Stands

Attacks by the red turpentine beetle occurred in residual lodgepole pines on experimental thinning plots established by the Bend Silviculture Laboratory. The attacked trees were first observed in mid-June, about one month after they had been attacked. Preliminary observations indicated about 5 percent of the residual trees had been attacked, with most trees receiving fewer than 5 attacks but a few as many as 15. Because of the experimental nature of the thinnings in which very precise levels of stocking had been established, the silviculture laboratory expressed great concern over the possibility of tree mortality. In response to a request as to how that possibility might be reduced, the laboratory was advised that, because fewer than 50 trees were attacked in an area less than 10 acres in size, manual extraction of the attacking beetles probably was the most feasible means of reducing the possibility of tree mortality.

The author accompanied a technician to the experimental area in July and showed him how the beetles could be extracted, with a minimum of damage to the trees. All the beetles were extracted from attacked trees on two of the 10 plots. Each of these two plots, which were believed to be typical, contained between 50 and 70 trees, with about 5 trees attacked on each plot. Half of the attacked trees had fewer than 5 attacks, and only 1 tree had more than 10 attacks. At the time of extraction, most beetles were present but had not begun to lay eggs. However, in many trees with more than 5 attacks, activity of the parent beetles had resulted in destruction of sufficient cambial tissue to make it at least doubtful whether some of the attacked trees will survive.

The Silviculture Laboratory subsequently reported that additional attacks had occurred. Time did not allow the author to check their observation by the time this report was written. It is planned in the summer of 1964 to determine if additional attacks have occurred, to determine if any brood was developed in the attacked trees, and to determine what, if any, mortality occurred.

It should be noted that the red turpentine beetle was not uncommon in thinned ponderosa pine stands in the Bend area and elsewhere in the region, attacking both larger pieces of slash and the bases of some residual trees. Attacks in standing trees appeared to be more common in stands thinned this spring than in those thinned last fall. Although as many as 5 percent of the residual trees were attacked in some thinned stands, no tree mortality caused by D. valens was evident by the end of the summer.

These observations on the red turpentine beetle are more completely described in a file report. A similar report is planned on the observations to be made this coming spring on the additional attacks, brood development, and tree mortality in the silviculture laboratory's experimental thinning plots in lodgepole pine.

RECOMMENDATIONS FOR FUTURE STUDIES

The following future studies are suggested from the results of 1963 studies and observations:

Recommended future mountain pine beetle studies:

1. Additional seasonal history studies to determine:

    a. Variation between areas.

    b. Variation between seasons.

    c. Differences between host species.

    d. Differences between types of host material (i.e. standing trees--immature and mature, slash, windfalls, cull logs, etc.).

2. Further biological studies to determine:

    a. Fate of re-emerged parent beetles.

    b. Brood productivity in pole-sized ponderosa pine.

3. Silvicultural studies to determine:

    a. Sources for infestations in ponderosa pine pole stands.

    b. Influence of beetle activity on species composition of stands.

    c. Age at which ponderosa pine stands become susceptible to D. monticolae.

Recommended future Oregon pine ips studies:

1. Additional seasonal history studies to determine:

    a. Variation between seasons.

    b. Differences between types of host material.

    c. Influence of weather.

2. Further biological studies to determine:

    a. Differences in qualitative features of the populations or subpopulations attacking slash and those attacking living trees (i.e., vigor, size, sex ratio, etc.).

    b. Differences in attack and oviposition habits of new and parent adults.

    c. Variation in hibernation habits between seasons and areas.

3. Studies of host and silvicultural relations to determine:

    a. Relation of stand age at time of thinning to subsequent ips killing.

    b. Relation of parent soil type to history of ips activity.

    c. Relation of physiological condition of trees and their susceptibility to ips attack.

4. Further studies to improve techniques for:

    a. Rearing beetles.

    b. Making forced attacks.

    c. Measuring physiological condition of trees.

Recommended future studies on other pine bark beetles:

1. Assessment of the importance of Dendroctonus valens as a tree killer in recently thinned stands of ponderosa pine and lodgepole pine.

COOPERATION

National Forest Administration provided assistance in maintenance of some of the ips seasonal history rearings. They and the Bureau of Indian Affairs assisted in locating suitable sites for study of the silvicultural relations of the mountain pine beetle. The Bend Silviculture Laboratory, Pacific Northwest Forest and Range Experiment Station made available lodging and laboratory facilities at the Pringle Falls Experimental Forest headuqarters, provided instruction in use of a nuclear-probe soil moisture instrument, and made available data on soil moisture levels for the 1963 season in the Pringle Falls area.

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